J Public Health (2011) 19:191–203
DOI 10.1007/s10389-010-0366-2

REVIEW ARTICLE

Epidemiology and risk factors of HCV infection among hemodialysis patients in countries of the Eastern Mediterranean Regional Office of WHO (EMRO): a quantitative review of literature

Seyed-Moayed Alavian · Seyed-Vahid Tabatabaei · Nastaran Mahboobi

Received: 30 April 2010 / Accepted: 13 September 2010 / Published online: 5 October 2010

Abstract
Background Hepatitis C virus infection (HCV) is the major co-morbidity of patients on chronic hemodialysis. There are many scattered and heterogeneous data about this infection in hemodialysis patients living in countries of the Eastern Mediterranean Region Office of WHO (EMRO) and its distribution is unknown in this region.
Aims To provide a more comprehensive tabulation of available data on the epidemiological characteristics and risk factors for HCV infection in hemodialysis patients in Iran and other EMRO countries.
Methods A systematic review was carried out based on the computerized literature databases. In all, 95% confidence intervals of infection rates were calculated using the approximate normal distribution model. Pooled odds ratios and 95% CIs were calculated by random effects models. The heterogeneity was assessed by either Q or χ^2 statistics and quantified by I^2.
Results We identified 62 studies that fulfilled our inclusion criteria involving 17,846 hemodialysis subjects. A total of 5,704 (32%) patients had positive serology for HCV infection. The prevalence ranged from 6–72% across countries. Pooled HCV seroprevalence was 17% (95% CI 13–20), 63% (95% CI 61–64), 48% (95% CI 45–51), 72% (95% CI 68–76), 23% (95% CI 21–24) in Iran, Saudi Arabia, Egypt, Morocco and Tunisia respectively. Hemodialysis duration OR=7.63 (95% CI 4.64–12.53), transfusion OR=2.06 (95% CI 1.47–2.89) and previous transplantation failure OR=2.66 (95% CI 1.46–4.86) were major risk factors of HCV infection. Age, sex and dialysis session/week were not associated with infection rate.
Conclusion Nearly 32% (95% CI 31–33) of hemodialysis patients in the EMRO countries are infected with HCV. Despite evolution of new strategies to confine HCV transmission among hemodialysis patients, nosocomial transmission is still the major route of HCV infection in these patients in this region.

Keywords Systematic review · Meta-analysis · Hemodialysis · EMRO · Iran · HCV

S.-M. Alavian (✉) · S.-V. Tabatabaei
Baqiyatallah Research Center for Gastroenterology and Liver Diseases, Baqiyatallah University of Medical Sciences, Ground floor of Baqiyatallah Hospital, Mollasadra Ave., Vanak Sq, P.O. Box 14155-3651, Tehran, Iran
e-mail: alavian@thc.ir

N. Mahboobi
Tehran Hepatitis Center (THC), No. 183 Ferdowsi Square, Sepahbod Gharani St., Tehran, Iran

Introduction

Hepatitis C virus (HCV) infection is a major public health problem worldwide (Alavian et al. 2005; Albuquerque et al. 2005; Boulaajaj et al. 2005; Alavian 2009) and patients on hemodialysis are at a much higher risk of acquiring HCV infection (Barril 2000; Salama et al. 2000; Alavian et al. 2007). Advancements of hemodialysis techniques have dramatically improved patients' survival of end-stage renal disease. As duration of hemodialysis is known as one of HCV infection risk factors, this increased survival has consequently led to an increased risk of getting infected by HCV among hemodialysis patients. Distribution of HCV infection among hemodialysis patients is not homogenous

globally, and seemingly, is higher in developing countries (Alavian 2009). In addition to different HCV prevalence among hemodialysis patients across different countries, enormous heterogeneity exists between reports from various parts of the same country (Jadoul et al. 1998). There are reports stating that HCV prevalence among hemodialysis patients is in a declining trend (Alavian et al. 2008), and this decline has mostly been attributed to strict adherence of hemodialysis centers to universal precautions (Baril and Traver 2003; Saxena et al. 2003; Yang et al. 2003; Jadoul et al. 2004; Shamshirsaz et al. 2004; Carneiro et al. 2005; Gallego et al. 2006). HCV epidemiological changes have been reported to be more prominent in the USA and European countries (dos Santos et al. 1996; Espinosa et al. 2004). To track these epidemiological changes in the Eastern Mediterranean Region Office of WHO (EMRO), where our country lies, we undertook a literature review. According to our results, adequate and reliable data from developing countries in this region are missing, the majority of available data from these countries are old and dated, heterogeneous and suffering from small sample sizes. Hence, to provide a more comprehensive presentation of available data, we expanded our narrative literature review to a systematic review on epidemiological characteristics and risk factors of HCV infection among hemodialysis patients of EMRO countries and tried to quantitatively analyze available epidemiological data from this region.

Materials and methods

Literature search

Electronic databases including Medline, Scopus and ISI were searched for seroepidemiological data of HCV infection among hemodialysis patients in EMRO countries. Our search was performed without temporal limits by different combinations of the following keywords: 'hemodialysis' or 'haemodialysis' or 'dialysis' or 'end stage renal disease', 'hepatitis C virus' or 'HCV' or 'chronic hepatitis C'. The names of EMRO countries that were added to our search strategy are as follows: Iran, Iraq, Afghanistan, Pakistan, Bahrain, Kuwait, Jordan, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen, West Bank, Egypt, Libyan Arab Jamahiriya, Djibouti, Morocco, Somalia, Sudan and Tunisia. Additionally, Persian-specific databases including SID, EMR Medex, websites of Iranian universities, Iran Medex and MagIran were searched using the aforementioned keywords. PakMediNet, the database of biomedical publications in Pakistan, was also accessed and searched via relevant keywords. Websites of regional journals from WHO-EMRO indexing site were browsed as well.

Selection of studies and data extraction

All studies that were published in English fulfilling the following criteria were considered eligible: (1) study design: cohort, case control, cross-sectional; (2) sample origin: patients on maintenance hemodialysis; (3) studies using enzyme immunoassay for anti-HCV antibody testing; (4) studies reporting anti-HCV antibodies among hemodialysis patients in EMRO countries. In addition to presenting confusing data, including subjects with symptomatic liver diseases, our exclusion criteria were patients on peritoneal hemodialysis or on hemodialysis because of acute renal failure. Titles and abstracts of all potentially relevant studies obtained through the search strategy were screened by a single investigator (S.V.T) to find eligible studies. If there was any uncertainty, it was settled by consulting the supervisor of this investigation (S.M.A). The following information was sought from each eligible study: first author's name, year of publication, country of sample's origin, type of study (cohort, case control or cross-sectional), sample size, generation of ELISA, confirmation with RIBA, mean/median age of subjects, percent of male subjects, mean/median duration of hemodialysis, number of subjects with positive anti-HCV and the percentage of HCV prevalence with 95% CI.

Quantitative analysis

The 95% CIs of the seroprevalence of anti-HCV antibody among hemodialysis patients for each of the included studies were computed using the approximate normal distribution model. The pooled estimate of anti-HCV Ab seropositivity rates accompany with 95% CIs for each country was computed if there were more than two studies. For Iranian studies, random effects model of DerSimonian and Laird was used to calculate pooled infection rate. The random effects model provides a more conservative estimate of significance. This model operates under the assumption that included studies are only a random sample of all studies that will be conducted so that heterogeneity between individual studies will result in a wider confidence interval of the summary estimate. Therefore, using the DerSimonian and Laird random effects model, the reported summary estimate was calculated as an average of the individual study results weighted by the inverse of their variances—variance for each study is the sum of the variance within studies plus the variance between studies; Michael Borenstein et al. (2009). Because there were significant heterogeneity in studies from Iranian provinces and other EMRO countries as well as a low number of studies and subjects, the random effects model was going to yield a wide range of HCV serostatus estimate; thus, to reach a meaningful estimate of infection rate in Iranian

provinces and other EMRO countries, we applied a fixed effect model of inverse variance. Under the fixed-effect model we assume that there is one true estimate which underlies all the studies in the analysis, and that all differences in observed results are due to sampling error (variance between studies are assumed zero). In this model, the summary estimate is an average of the individual study results weighted by the inverse of their within-study variances that result in tighter CIs for summary estimate. This model puts less weight on small studies than the random effects model; therefore, it is less affected by the presence of publication bias. The estimate of heterogeneity was taken from the Mantel-Haenszel model for odds ratios of reported risk factors; under the null hypothesis of the test of heterogeneity, there is no difference in the treatment effect between groups (this follows a χ^2 distribution with a $k-1$ degree of freedom, where k is the number of studies contributing to the meta-analysis. Heterogeneity estimation for HCV infection rates was made using a Q statistic under the same null hypothesis. Study results were considered heterogeneous if the resultant P-value was less than 0.1 (Petitti 2000). I^2 was also used to provide a measure of the degree of inconsistency in the studies' results. Its quantity, describes the percentage of total variation across studies, due to heterogeneity rather than chance. I^2 lies between 0 and 100%. A value of 0% indicates no observed heterogeneity, and larger values show increasing heterogeneity (Higgins et al. 2003).

Results

Based on data provided in titles and abstracts, we retrieved 64 relevant manuscripts that evaluated anti-HCV serostatus in patients on maintenance hemodialysis from EMRO countries. These studies were carefully examined to avoid the inclusion of overlapping reports. Accordingly, two studies with duplicate data of the same patients were excluded (al-Dhahry et al. 1992; Qadi et al. 2004). Furthermore, one study was deleted for methodological

Table 1 Characteristics of included patients and studies from Iran (individual and pooled estimates of HCV infection are presented in Figs. 1 and 2)

Author and Date	Province	Design	Sample size	ELISA	RIBA	Mean age	Male %	Dialysis duration
(Rais-Jalali and Khajehdehi 1999)	Fars	C-S	182	2nd	No	48	61%	28
(Mohammad-Alizadeh et al. 2002)	Hamadan	C-S	96	2nd	No	52	54%	11
(Broumand et al. 2002)	Tehran	CS	548	3rd	Yes	NR	NR	NR
(Alavian et al. 2003)	Tehran	C	838	3rd	Yes	50	56%	4.4
(Toosi et al. 2008)	Tehran	C-S	130	3rd	No	NR	NR	NR
(Nemati et al. 2009)	Tehran	C	112	2nd	No	59	54%	30
(Alavian et al. 2004)	Qazvin	C-S	68	2nd	Yes	51	53%	40
(Bozorghi et al. 2006)	Qazvin	C-S	89	3rd	Yes	51	NR	NR
(Seyrafian et al. 2006)	Isfahan	C-C	556	3rd	No	NR	NR	NR
(Ghomi et al. 2006)	Qom	C-S	236	2nd	Yes	NR	NR	NR
(Samimi-Rad et al. 2008)	Markazi	C-C	204	3rd	Yes	54	50%	39
(Ansar and Kooloobandi 2002)	Guilan	C-C	93	2nd	Yes	NR	NR	NR
(Amiri et al. 2005)	Guilan	C-S	298	2nd	Yes	52.2	52%	≥48 (21%)
(Dadgaran 2005)	Guilan	C-S	393	2nd	No	54	59%	≥36 (38%)
(Taziki and Espahbodi 2008)	Mazandaran	C	497	3rd	No	[a]	[a]	[a]
8(Makhloogh et al. 2008)	Mazandaran	C-S	186	3rd	No	58	65%	36
(Sorkhi et al. 2008)	Mazandaran	C-S	62	3rd	Yes	51	45%	>60 (6.5%)
(Jabbari et al. 2008)	Golestan	C	93	2nd	Yes	47	55%	48
(Assarehzadegan et al. 2009)	Khuzestan	C-S	214	3rd	No	37	63%	NR
(Somi et al. 2007)	Eastern Azerbaijan	C-S	462	3rd	Yes	53	55%	>36 (40%)
(Kheradpezhouh et al. 2007)	Eastern Azerbaijan	C-S	324	2nd	No	53	59%	53
(Saboor et al. 2003)	Kermanshah	C-S	140	2nd	No	[a]	[a]	[a]

[a] Blank boxes are related to data that have not been mentioned in abstracts of the manuscripts which full texts were not available to us

C-S cross-sectional studies; *C* cohort studies; *C-C* case-control studies; *NR* not reported

Table 2 characteristics of studies and patients in EMRO countries (pooled estimates are presented in Fig. 3)

Country	Author and date	Design	Sample size	ELISA	RIBA	Mean age	Male %	Dialysis duration	No. of positive cases	Prevalence 95% CI
Pakistan	(Gul and Iqbal 2003)	c-c	50	2nd	No	40	50%	NR	34	68% (55–81)
	(Khokhar et al. 2005)	C-S	97	2nd	No	NR	66%	22	23	24% (16–32)
Iraq	(Khattab 2008)	C	169	3rd	No	36	60%	11	12	7% (3–11)
Bahrain	(Almawi et al. 2004)	C-C	81	NR	No	NR	NR	NR	7	9% (3–15)
Kuwait	(El-Reshaid et al. 1995)	C-S	196	2nd	No	50	49%	18	88	45% (38–52)
Jordan	(Said et al. 1995)	C-S	273	2nd	No	NR	NR	NR	67	25% (20–30)
Lebanon	(Abdelnour et al. 1997)	C-S	108	[a]	No	[a]	[a]	[a]	17	16% (10–24)
Oman	(al-Dhahry et al. 1993)	C-C	102	[a]	No	[a]	[a]	[a]	27	27% (19–36)
Qatar	(Abboud et al. 1995)	C	130	NR	Yes	NR	NR	38	58	45% (36–53)
Saudi Arabia	(Fakunle et al. 1991)	C-S	190	[a]	No	40	[a]	[a]	102	54% (47–61)
	(Bernieh et al. 1995)	C-S	94	2nd	No	47	45%	39	56	60% (50–70)
	(Omar et al. 1995)	C-S	149	2nd	No	48	57%	NR	126	85% (79–90)
	(Souqiyyeh et al. 1995)	C	1392	2nd	No	45	53%	36	974	70% (68–72)
	(Al Shohaib et al. 1995)	C-S	139	2nd	No	NR	NR	NR	73	53% (44–61)
	(Shaheen et al. 1995)	C-S	408	2nd	No	43	52%	52	295	72% (68–77)
	(Al-Muhanna 1995)	C-S	162	2nd	Yes	NR	NR	NR	70	43% (35–50)
	(Soyannwo et al. 1996)	C-S	96	[a]	No	[a]	49%	[a]	48	50% (40–60)
	(Saxena et al. 2001)	C-S	189	3rd	Yes	48	48%	74	83	44% (37–51)
	(Al-Jiffri et al. 2003)	C-S	248	NR	No	NR	NR	55	180	73% (67–78)
	(Kashem et al. 2003)	C-S	90	4th	Yes	45	52%	48	42	47% (36–57)
	(Hussein et al. 2007)	C	180	3rd	No	55	48%	NR	34	19% (13–25)
Syria	(Abdulkarim et al. 1998)	C-S	120	2nd	No	NR	NR	NR	90	75% (67–83)
	(Othman and Monem 2001)	C-C	139	3rd	No	NR	58%	>36 (43%)	95	68% (60–76)
	(Moukeh et al. 2009)	C-S	550	NR	NR	45	51%	>120 (4%)	290	54% (50–58)
Emirates	(El Shahat et al. 1995)	C	262	2nd	Yes	42	68%	21	64	24% (20–30)
Yemen	(Haidar 2002)	C-C	30	3rd	No	NR	NR	NR	12	40% (22–58)
Egypt	(Abdel-Wahab et al. 1994)	C-C	170	2nd	No	NR	NR	NR	78	46% (39–53)
	(Gohar et al. 1995)	C-C	64	[a]	No	[a]	[a]	[a]	56	88% (80–96)
	(Abdel Hady et al. 1998)	C-C	96	[a]	No	[a]	[a]	[a]	26	27% (18–36)
	(El-Zayadi et al. 1999)	C-S	79	[a]	No	[a]	[a]	[a]	11	14% (6–22)
	(Hassan and Khalil 2000)	C-S	210	2nd	Yes	48	NR	27	125	59% (52–66)
Libya	(Elzouki et al. 1995)	C-S	153	2nd	No	42	62%	>12 (61%)	32	21% (14–27)
Morocco	(Boulaajaj et al. 2005)	C-S	186	[a]	No	[a]	v	104	141	76% (70–82)
	(Sekkat et al. 2008)	C-S	303	[a]	No	[a]	[a]	[a]	207	68% (63–74)
Sudan	(Suliman et al. 1995)	C-C	46	2nd	Yes	NR	74%	36	16	35% (22–49)

Tunisia	(Jemni et al. 1994)	C-S	63	2nd	No	[a]	[a]	[a]	27	42% (31–55)
	(Ayed et al. 2003)	C-S	4290	2nd	No	NR	NR	NR	960	22% (21–23)
	(Ben Othman et al. 2004)	C	276	3rd	No	[a]	[a]	[a]	90	33% (27–38)
	(Hmaied et al. 2006)	C	395	3rd	No	54	60%	NR	79	20% (16–24)

[a] Blank boxes are related to data that have not been mentioned in abstracts of the manuscripts which full texts were not available to us

C-S cross-sectional studies; *C* cohort studies; *C-C* case-control studies; *NR* not reported

reasons—the third generation of RIBA test was used for screening (al Meshari et al. 1995). According to what we found, no data were available from Djibouti, Somali and Afghanistan concerning HCV prevalence in their hemodialysis patients. Additionally, only 1 study was identified from Bahrain, Iraq, Kuwait, Jordan, Lebanon, Libya, Oman, Qatar, Emirates, Yemen and Sudan. Furthermore, 22 studies involving 5,821 subjects from Iran, 2 studies including 147 subjects from Pakistan, 12 studies with 3,337 subjects from Saudi Arabia, 3 studies with 809 subjects from Syria, 5 studies with 619 subjects from Egypt, 4 studies from Tunisia with 5,024 subjects and 2 studies including 489 subjects from Morocco have been found. The mean/median age of subjects ranged from 36 to 59 years, the male gender constituted 45–74% of the studied population and the mean/median duration of hemodialysis ranged from 4.4 to more than 120 months. Twelve studies had case-control (C-C) design, 11 were longitudinal (cohort) and the other 38 were simple cross-sectional (C-S) studies (Tables 1 and 2).

HCV infection rate among hemodialysis patients in EMRO countries

Table 1 and Fig. 1 show seroprevalence of HCV infection among hemodialysis patients in Iran. The point estimates ranged from 3 to 56%. The pooled estimate of infection in random effects model was 17%—(95% CI 13–20), $Q(22)=371$, $P=0$, $I^2=94\%$. In the fixed-effect model, the pooled estimate was 10% (95% CI 9–11). Figure 2 shows distribution of HCV infection in Iran according to the provinces that the studies have been conducted in. There were no studies from the eastern part of this country. Distribution of HCV infection in hemodialysis patients ranged from 3% in Isfahan to 28% in Golestan province. Golestan in northern and Kermanshah in western parts of Iran were the most prevalent provinces regarding HCV infection in hemodialysis patients, whereas the rate of infection was below 15% in other states (Fig. 2).

Table 2 shows the pooled or individual estimate of HCV infection rate in other EMRO countries. Pooled seroprevalence of HCV infection was 63% [(95% CI 61–64), $I^2=97\%$] in Saudi Arabia, 37% [(95% CI 30–44), $I^2=97\%$] in Pakistan, 61% [(95% CI 57–64), $I^2=92\%$] in Syria, 48% [(95% CI 45–51), $I^2=98\%$] in Egypt, 72% [(95% CI 68–76), $I^2=75\%$] in Morocco and 23% [(95% 21–24), $I^2=88\%$) in Tunisia. Figure 3 shows geographical distribution of HCV infection rate in EMRO region.

Eight studies had enrolled blood donors, dialysis staff or general population as a control group. The OR of HCV infection rate in hemodialysis patients vs. these control groups were 40.99 [(95% CI 7.88–213.30), $\chi^2(6)=194$, $I^2=97\%$] (Fig. 4).

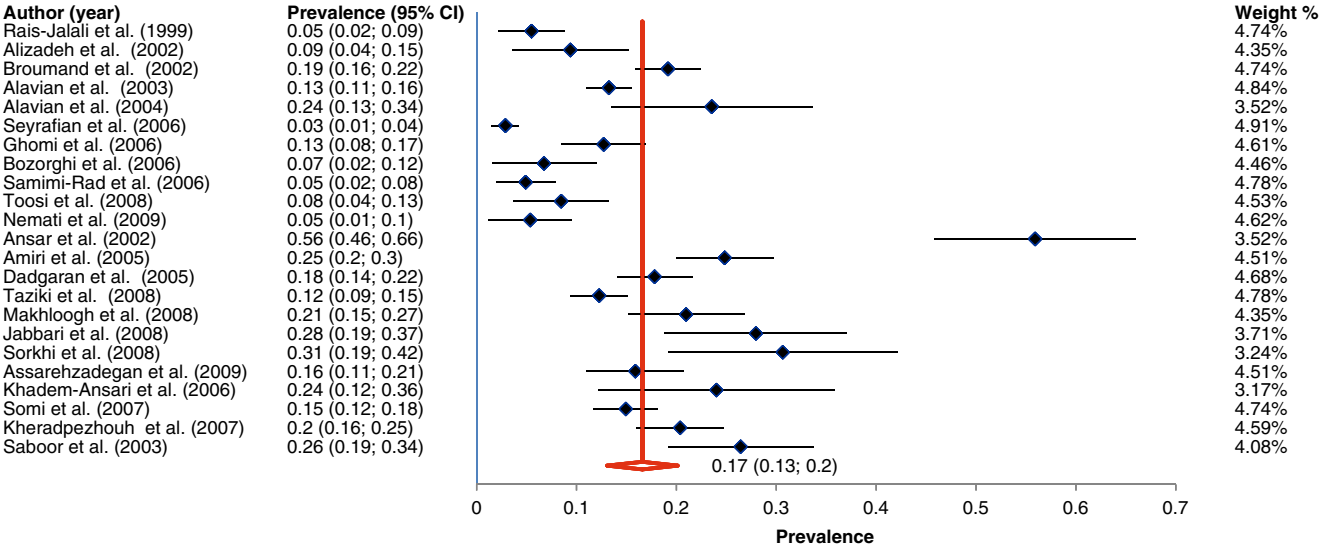

Fig. 1 Summary estimate of HCV infection rate among hemodialysis patients in Iran

Risk factors of HCV infection among hemodialysis patients in EMRO countries

We aggregated reported risk factors of HCV infection among hemodialysis patients across all studies from EMRO countries. These risk factors included long hemodialysis duration, history of previous blood transfusion, history of rejected allograft, male gender, older in age and three or more hemodialysis sessions per week. Because subjects were from different ethnicities and some reports were not accessible to us, we used the random-effects model of the DerSimonian and Laird method to identify statistically significant risk factors. This model is more conservative than the fixed-effect model and yields wider confidence interval for pooled estimates. The odds ratio (OR) was significant for long hemodialysis duration (Fig. 5), history

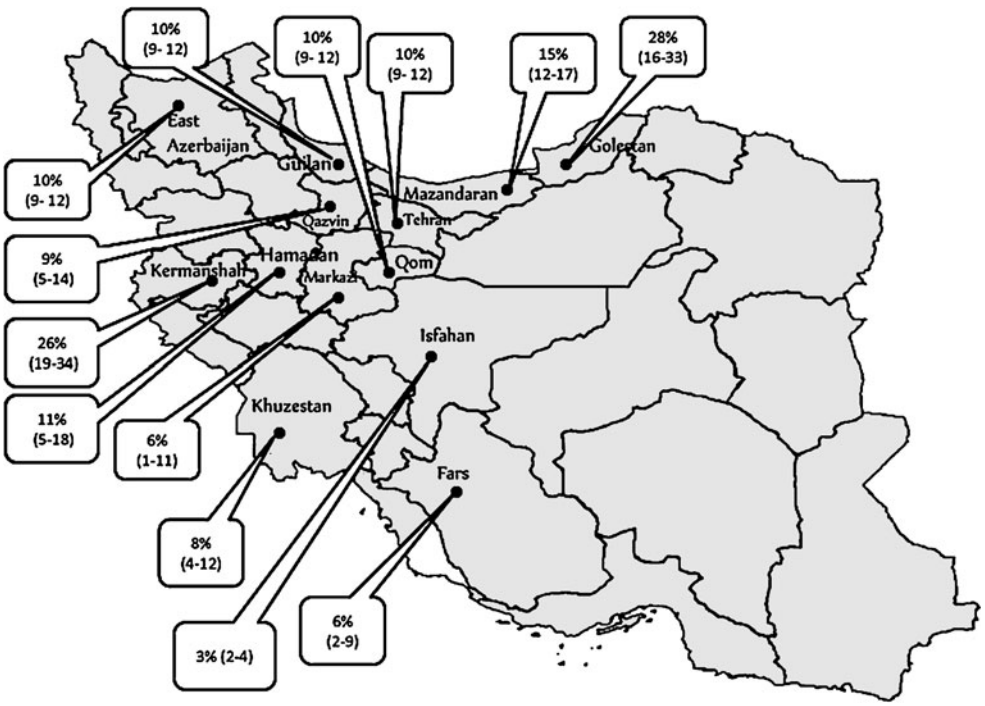

Fig. 2 Geographical distribution of HCV infection in hemodialysis patients in Iran

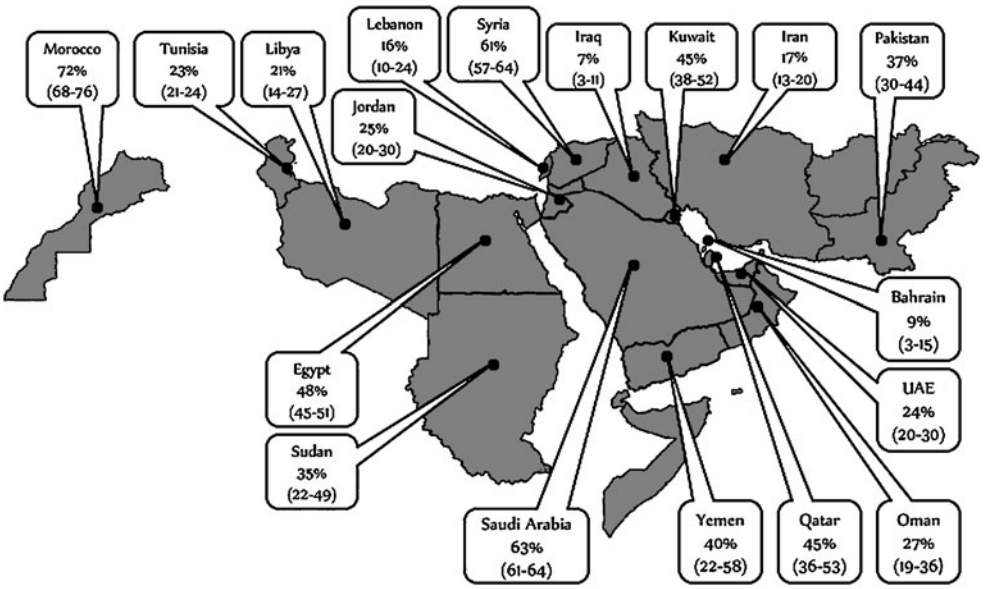

Fig. 3 Geographical distribution of HCV infection among hemodialysis patients in eastern Mediterranean region

of rejected allograft (Fig. 6) and history of blood transfusion (Fig. 7). The OR was non-significant for higher ages [0.93 (95% CI 0.58–1.51), I^2=0%], male gender [0.94 (95% 0.72–1.23), I^2=52%], and three dialysis session/week vs. lesser [1.84 (95% CI 0.65–5.18), I^2=70%].

Discussion

HCV prevalence among hemodialysis patients and its associated risk factors can help us to develop more efficient prevention strategies against this infection. As accurate data from EMRO countries are scarce in this regard, this systematic review was performed to provide a more robust viewpoint on the current situation of hemodialysis patients' HCV infection in this region. To be able to compare HCV prevalence in various countries, pooled estimates of HCV infection rate in hemodialysis patients were calculated for each of EMRO countries. Details of epidemiological data from various parts of the same country have been summarized in Tables 1 and 2. Due to what is shown in these tables, an obvious difference is seen between HCV infection reports from different parts of Iran, Tunisia, Egypt, Syria and Saudi Arabia. This difference can be attributed to several influencing factors. First, these studies were performed in different regions, with various HCV prevalences among their normal population. For instance, the pooled estimate of HCV infection in Iran was 16% and varied from 3% in Isfahan province (central Iran) to 28% in Golestan province (north east Iran). The higher rate of HCV infection in Golestan

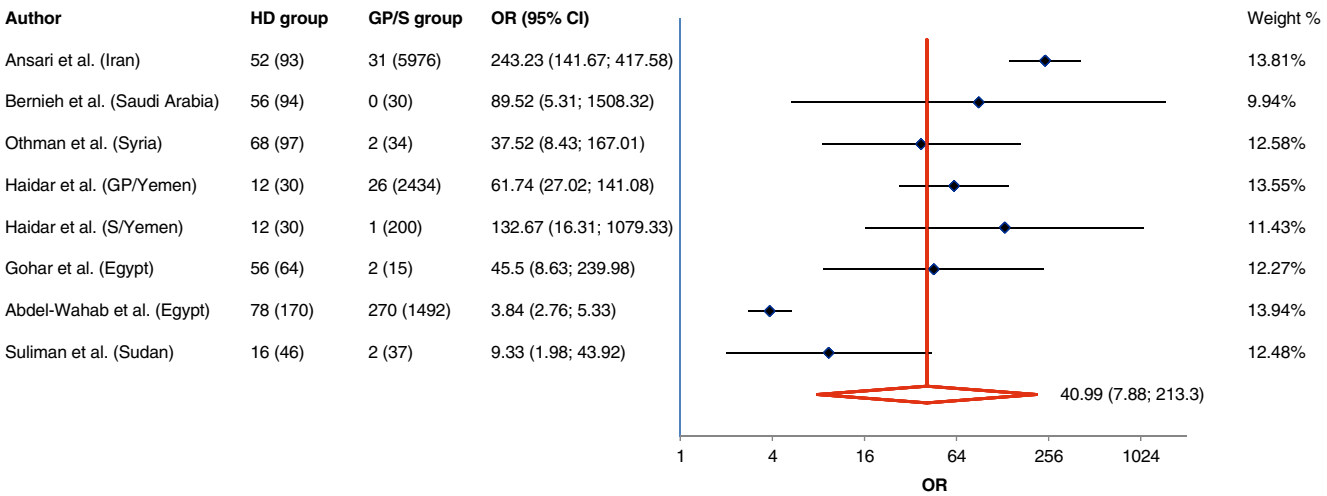

Fig. 4 Summary estimate of HCV infection rate in hemodialysis patients vs. general population\dialysis unit staffs\blood donors

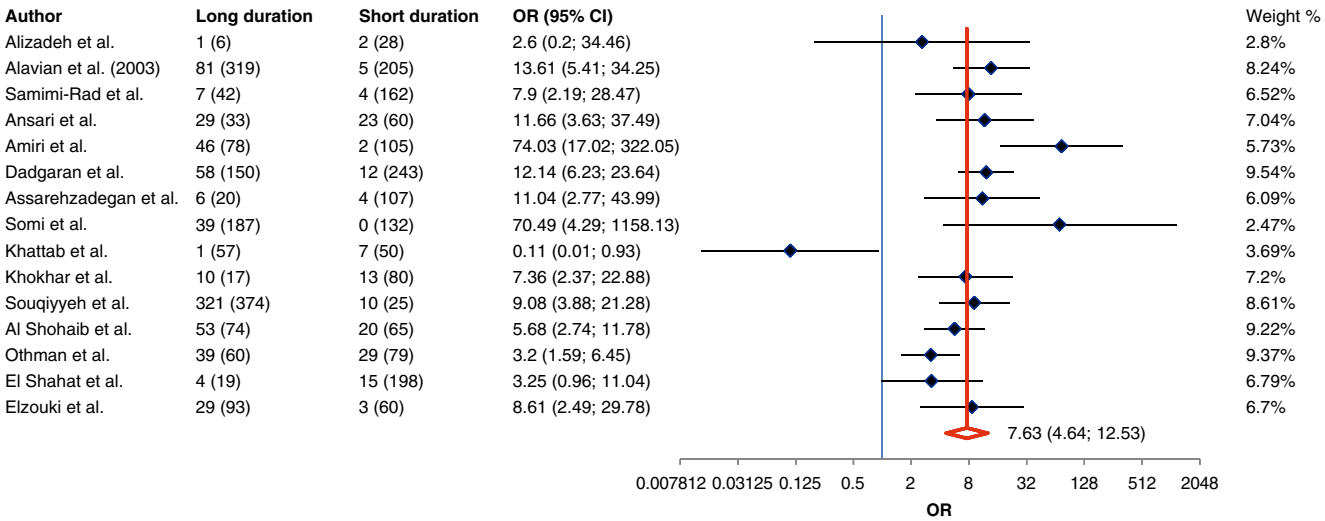

Fig. 5 Summary estimate of HCV infection rate in patients with a long hemodialysis duration vs. patients whose duration of hemodialysis has been short, the comparisons are reconstructed based on defined categories inside each study

province can be related to higher prevalence of infection in the general population in this area (Ghadir et al. 2006; Alavian et al. 2009). Second, adherence of hemodialysis centers to precautionary measures might be different between centers of various parts of the same country.

In addition to different HCV prevalences between various parts of the same country, HCV prevalence is different between different countries as well. According to our results, the pooled estimate of HCV infection was much higher in other EMRO countries than Iran. This higher prevalence can be attributed to a higher rate of HCV infection in the general population (Daw et al. 2002; Ameen et al. 2005; Alavian et al. 2009; Ali et al. 2009), ineffective health policies on handling HCV prevention programs and strategies (Alavian 2006), higher rate of HCV infection in blood donors (Kamel et al. 1992; Kafi-abad et al. 2009), loose programs regarding blood donors' HCV infection screening prior to transfusion (Rezvan et al. 2007) and limitation of available treatment resources for the rapidly growing hemodialysis population (Mahdavi-Mazdeh et al. 2008).

Besides HCV prevalence among hemodialysis patients of EMRO countries, risk factors of their getting infected by HCV were studied in the present review. Our results showed that nosocomial transmission (OR=7.63 for longer

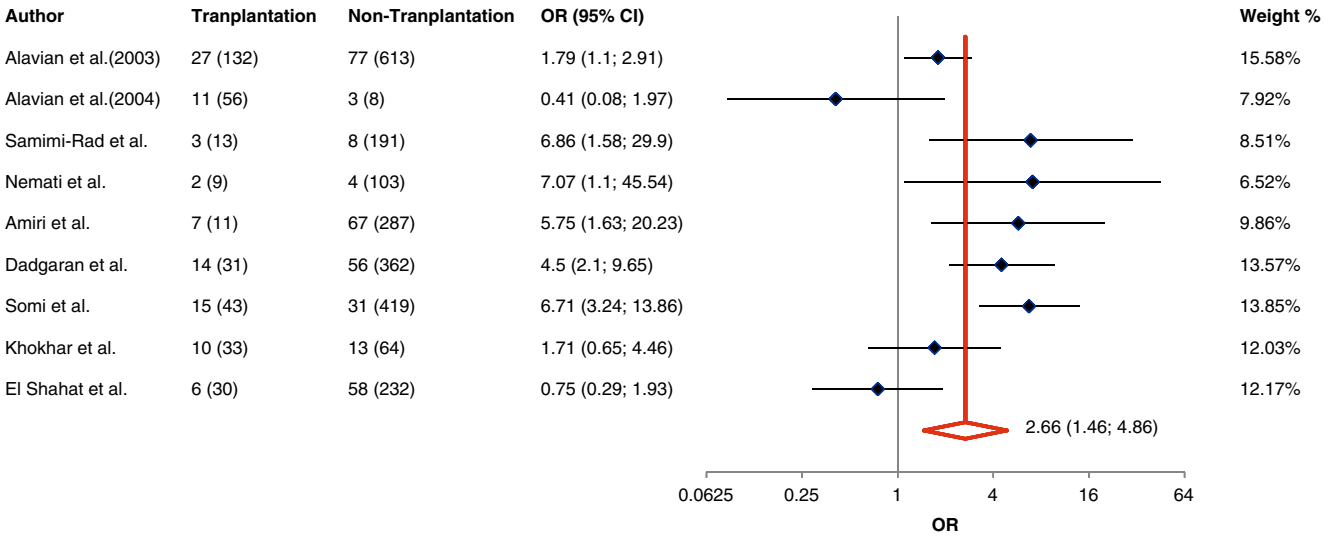

Fig. 6 Summary estimate of HCV infection rate in hemodialysis patients with history of allograph rejection vs. those who did not undergo transplantation

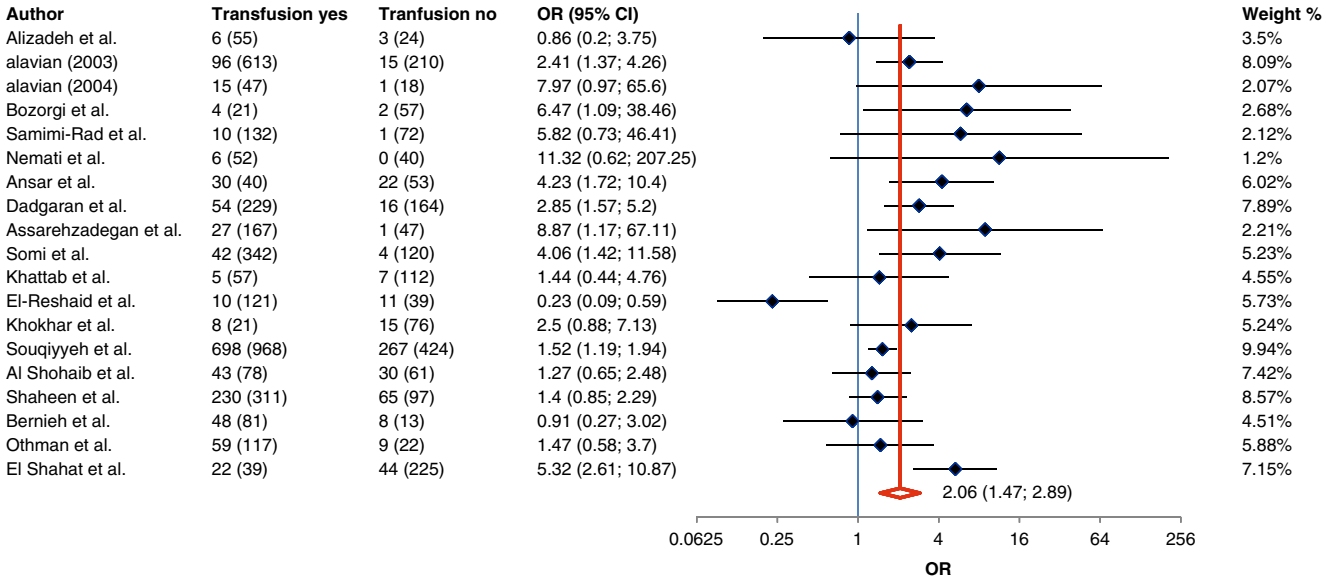

Fig. 7 Summary estimate of HCV infection rate in hemodialysis patients with history of blood transfusion vs. those who did not undergo transfusion

hemodialysis duration vs. 2.06 for transfusion and 2.66 for allograft rejection) is the key mode of HCV transmission in hemodialysis settings across EMRO countries. Therefore, universal infection control precautions are the keystone in prevention of HCV transmission through hemodialysis units in this area. Thus, screening all hemodialysis patients for the HCV antibody seems reasonable. Developing an online network to link all of the dialysis centers of the country and make it possible for them to share their obtained data might also be very helpful (Alavian 2006). Isolation measures such as health-care monitoring of infected patients and providing care in a distinct section of the unit can improve prevention results as well. Additionally, it is recommended that dialysis centers screen their patients for HCV antibody every 3–6 months and treat the positive patients. In this strategy, infected patients will be diagnosed in the acute phase of infection and their chance of sustained viral response will be increased. According to the fact that these patients serve as a reservoir of infection for other patients, staffs and transplantation team, this intervention will also limit the source of HCV infection. (Pol et al. 1993; Saab et al. 2001a, b. Clearly, diagnosis of new HCV infections will make the hemodialysis centers review their adherence to precautionary methods and increase their vigilance. Public health authorities' awareness of the prevalence and incidence of HCV infection in their local hemodialysis centers will encourage them to assess the risk factors of HCV infection among hemodialysis patients, and will facilitate changes in current policies. Successful control of infection requires further studies to assess the effectiveness of different preventive policies (Alavian 2009).

HCV infection does not seem to influence patient and graft survival within a medium-time follow up in living allograft recipients. Thus, renal transplantation will decrease the mortality rate of these patients. It will also diminish the risk of HCV transmission from infected patients to other hemodialysis patients. Therefore, placing these patients on the top of the kidney transplantation waiting lists is recommended.

To understand the comparative magnitude of HCV infection among hemodialysis patients in EMRO countries, we tried to locate epidemiological evidence from countries of other WHO regional offices. Due to the scattered nature of study findings across and within countries, we put our priority on systematic reviews, analysis of registries or international epidemiological projects. If it was not possible, we picked the most populated country or countries within each region with accessible data as representative for comparison purposes.

Investigation of prevalent data recorded in the national or regional dialysis registries of the 10 Asia-Pacific countries/areas (Australia, New Zealand, Japan, China, Taiwan, Korea, Thailand, Hong Kong, Malaysia and India) between 1995 and 2005, comprising 201,590 patients, has shown an HCV infection rate of 0.7–18.1% (Johnson et al. 2009). Very few data are available from countries of the WHO South East Asia region. The HCV infection rate was reported between 4.3 and 46% in India, the major country in this region (Reddy et al. 2005; Chandra et al. 2004; Agarwal et al. 1999; Jasuja et al. 2009). From the WHO Africa region, we could only find one old study from South Africa that reported HCV an infection rate of 22.6% (Soni et al. 1993). It seems that HCV prevalence In the WHO

European Region is very low. Results of the European Dialysis and Transplantation Association (EDTA) study on 4,724 hemodialysis patients who were studied at the baseline in 68 centers, revealed that only 13 (0.27%) patients were found to have the HCV antibody seroconverted during the 12 months of study. These HCV antibody seroconversions occurred in seven hospitals within five different countries (Zampieron et al. 2006). In the WHO Americas region, HCV prevalence among hemodialysis patients are 7.1% in Mexico (Paniagua et al. 2010), 5.4% in Canada (Tu et al. 2009), and 11% in Brazil (Freitas et al. 2008). To sum up, it appears that HCV prevalence in hemodialysis patients of the WHO Eastern Mediterranean region is significantly higher than hemodialysis patients of the European, Americas and Western Pacific regions. Due to heterogeneity and scarcity of data, no comparison could be made between the WHO Africa and South-East Asia region.

Conclusion

Nearly 32% (95% CI 31–33) of hemodialysis patients in the EMRO countries are infected with HCV. Despite the evolution of new strategies to confine HCV transmission among hemodialysis patients, nosocomial transmission is still the major route of HCV infection in these patients in this region.

Conflict of interest The authors declare that they have no conflicts of interest relevant to this manuscript. This work was not granted from any industry or organization.

References

Abboud O, Rashid A, Al-Kaabi S (1995) Hepatitis C virus infection in hemodialysis patients in Qatar. Saudi J Kidney Dis Transplant 6:151–153

Abdel-Wahab MF, Zakaria S, Kamel M et al (1994) High seroprevalence of hepatitis C infection among risk groups in Egypt. Am J Trop Med Hyg 51:563–567

Abdel Hady SI, El-Din MS, El-Din ME (1998) A high hepatitis E virus (HEV) seroprevalence among unpaid blood donors and haemodialysis patients in Egypt. J Egypt Public Health Assoc 73:165–179

Abdelnour GE, Matar GM, Sharara HM, Abdelnoor AM (1997) Detection of anti-hepatitis C-virus antibodies and hepatitis C-virus RNA in Lebanese hemodialysis patients. Eur J Epidemiol 13:863–867

Abdulkarim AS, Zein NN, Germer JJ et al (1998) Hepatitis C virus genotypes and hepatitis G virus in hemodialysis patients from Syria: identification of two novel hepatitis C virus subtypes. Am J Trop Med Hyg 59:571–576

Agarwal SK, Dash SC et al (1999) Hepatitis C virus infection during haemodialysis in India. J Assoc Physicians India 47:1139–1143

al-Dhahry SH, Aghanashinikar PN, Al-Hasani MK, Buhl MR, Daar AS (1992) Antibodies to hepatitis C virus in Omani patients with renal disease. Transplant Proc 24:1938–1939

al-Dhahry SH, Aghanashinikar PN, Al-Hasani MK, Buhl MR, Daar AS (1993) Prevalence of antibodies to hepatitis C virus among Omani patients with renal disease. Infection 21:164–167

Al-Jiffri AM, Fadag RB, Ghabrah TM, Ibrahim A (2003) Hepatitis C virus infection among patients on hemodialysis in Jeddah: a single center experience. Saudi J Kidney Dis Transplant 14:84–89

Al-Muhanna FA (1995) Hepatitis C virus infection among hemodialysis patients in the eastern region of Saudi Arabia. Saudi J Kidney Dis Transplant 6:125–127

al Meshari K, al Ahdal M, Alfurayh O, Ali A, De Vol E, Kessie G (1995) New insights into hepatitis C virus infection of hemodialysis patients: the implications. Am J Kidney Dis 25:572–578

Al Shohaib SS, Abdelaal MA, Zawawi TH, Abbas FM, Shaheen FA, Amoah E (1995) The prevalence of hepatitis C virus antibodies among hemodialysis patients in the Jeddah area, Saudi Arabia. Saudi J Kidney Dis Transplant 6:128–131

Alavian SM (2006) Hepatitis C, chronic renal failure, control is possible! Hepat Mon 6:51–552

Alavian SM (2009) A shield against a monster: hepatitis C in hemodialysis patients. World J Gastroenterol 15:641–646

Alavian SM, Einollahi B, Hajarizadeh B, Bakhtiari S, Nafar M, Ahrabi S (2003) Prevalence of hepatitis C virus infection and related risk factors among Iranian haemodialysis patients. Nephrology (Carlton) 8:256–260

Alavian SM, Kafaee J, Yektaparast B, Rad N, Bakhtiari S, Hajarizadeh B, Sadri M (2004) Prevalence and risk factors for acquiring hepatitis C in hemodialysis patients in Gazvin (2001) (in Persian). J Qazvin Univ Med Sci 29:16–20

Alavian SM, Adibi P, Zali MR (2005) Hepatitis C virus in Iran: epidemiology of an emerging infection. Arch Iran Med 8:84–90

Alavian SM, Hosseini-Moghaddam SM, Rahnavardi M (2007) Hepatitis C among hemodialysis patients: a review on epidemiologic, diagnostic, and therapeutic features. Hepat Mon 7:153–162

Alavian SM, Bagheri-Lankarani K, Mahdavi-Mazdeh M, Nourozi S (2008) Hepatitis B and C in dialysis units in Iran: changing the epidemiology. Hemodial Int 12:378–382

Alavian SM, Ahmadzad Asl M, Bagheri-Lankarani K, Shahbabaie MA, Bahrami Ahmadi A (2009) Hepatitis C infection in the general population of Iran: a systematic review. Hepat Mon 9:211–223

Albuquerque AC, Coelho MR, Lopes EP, Lemos MF, Moreira RC (2005) Prevalence and risk factors of hepatitis C virus infection in hemodialysis patients from one center in Recife, Brazil. Mem Inst Oswaldo Cruz 100:467–470

Ali SA, Donahue RM, Qureshi H, Vermund SH (2009) Hepatitis B and hepatitis C in Pakistan: prevalence and risk factors. Int J Infect Dis 13:9–19

Almawi WY, Qadi AA, Tamim H, Ameen G, Bu-Ali A, Arrayid S, Abou Jaoude MM (2004) Seroprevalence of hepatitis C virus and hepatitis B virus among dialysis patients in Bahrain and Saudi Arabia. Transplant Proc 36:1824–1826

Ameen RN, Sanad N, Al-Shemmari S, Siddique I, Chowdhury RI, Al-Hamdan S, Al-Bashir A (2005) Prevalence of viral markers among first-time Arab blood donors in Kuwait. Transfusion 45:1973–1980

Amiri ZM, Shakib AJ, Toorchi M (2005) Seroprevalence of hepatitis C and risk factors in haemodialysis patients in Guilan, Islamic Republic of Iran. East Mediterr Health J 11:372–376

Ansar MM, Kooloobandi A (2002) Prevalence of hepatitis C virus infection in thalassemia and haemodialysis patients in north Iran-Rasht. J Viral Hepat 9:390–392

Assarehzadegan MA, Shakerinejad G, Noroozkohnejad R, Amini A, Rahim Rezaee SA (2009) Prevalence of hepatitis C and B infection and HC V genotypes among hemodialysis patients in Khuzestan province, southwest Iran. Saudi J Kidney Dis Transplant 20:681–684

Ayed K, Gorgi Y, Ben Abdallah T, Aouadi H, Jendoubi-Ayed S, Sfar I, Makni H (2003) Hepatitis C virus infection in hemodialysis patients from Tunisia: national survey by serologic and molecular methods. Transplant Proc 35:2573–2575

Barril G (2000) Hepatitis C virus-induced liver disease in dialysis patients. Nephrol Dial Transplant 15(Suppl 8):42–45

Baril G, Traver JA (2003) Decrease in the hepatitis C virus (HCV) prevalence in hemodialysis patients in Spain: effect of time, initiating HCV prevalence studies and adoption of isolation measures. Antivir Res 60:129–134

Ben Othman S, Bouzgarrou N, Achour A, Bourlet T, Pozzetto B, Trabelsi A (2004) High prevalence and incidence of hepatitis C virus infections among dialysis patients in the East-Centre part of Tunisia. Pathol Biol (Paris) 52:323–327

Bernieh B, Allam M, Halepota A, Mohamed AO, Parkar J, Tabbakh A (1995) Prevalence of hepatitis C virus antibodies in hemodialysis patients in madinah Al munawarah. Saudi J Kidney Dis Transplant 6:132–135

Borenstein M, Hedges LV, Higgins JPT, Rothstein H (2009) Introduction to meta-analysis. Wiley, New York

Boulaajaj K, Elomari Y, Elmaliki B, Madkouri B, Zaid D, Benchemsi N (2005) Prevalence of hepatitis C, hepatitis B and HIV infection among haemodialysis patients in Ibn-Rochd University Hospital, Casablanca. Néphrol Thér 1:274–284

Bozorghi SH, Ramezany H, Vahid T (2006) Assessment of prevalence and risk factors of hepatitis C virus infection in haemodialysis patients in Ghazvin (In Persian). Sci J IBTO 2:331–337

Broumand B, Abdollah-Shamshirsaz AR, Kamgar M (2002) Prevalence of hepatitis C infection and its risk factors in hemodialysis patients in Tehran: preliminary report from "the effect of dialysis unit isolation on the incidence of hepatitis C in dialysis patients" project. Saudi J Kidney Dis Transplant 13:467–472

Carneiro MA, Teles SA, Dias MA (2005) Decline of hepatitis C infection in hemodialysis patients in central Brazil: a ten years of surveillance. Mem Inst Oswaldo Cruz 100:345–349

Chandra M, Khaja MN et al (2004) Prevalence of hepatitis B and hepatitis C viral infections in Indian patients with chronic renal failure. Intervirology 47:374–376

Dadgaran SA (2005) Prevalence and risk factors of hepatitis C virus among hemodialysis patients. J Guilan Univ 55:76–86

Daw MA, Elkaber MA, Drah AM, Werfalli MM, Mihat AA, Siala IM (2002) Prevalence of hepatitis C virus antibodies among different populations of relative and attributable risk. Saudi Med J 23:1356–1360

dos Santos JP, Loureiro A, Cendoroglo Neto M, Pereira BJ (1996) Impact of dialysis room and reuse strategies on the incidence of hepatitis C virus infection in haemodialysis units. Nephrol Dial Transplant 11:2017–2022

El-Reshaid K, Kapoor M, Sugathan T, Al-Mufti S, Al-Hilali N (1995) Hepatitis C virus infection in patients on maintenance dialysis in Kuwait: epidemiological profile and efficacy of prophylaxis. Saudi J Kidney Dis Transplant 6:144–150

El-Zayadi AR, Abe K, Selim O, Naito H, Hess G, Ahdy A (1999) Prevalence of GBV-C/hepatitis G virus viraemia among blood donors, health care personnel, chronic non-B non-C hepatitis, chronic hepatitis C and hemodialysis patients in Egypt. J Virol Methods 80:53–58

El Shahat YI, Varma S, Bari MZ, Shah Nawaz M, Abdulrahman S, Pingle A (1995) Hepatitis C virus infection among dialysis patients in United Arab Emirates. Saudi J Kidney Dis Transplant 6:157–162

Elzouki AN, Bushala M, Tobji RS, Khfaifi M (1995) Prevalence of anti-hepatitis C virus antibodies and hepatitis C virus viraemia in chronic haemodialysis patients in Libya. Nephrol Dial Transplant 10:475–476

Espinosa M, Martn-Malo A, Ojeda R, Santamara R, Soriano S, Aguera M, Aljama P (2004) Marked reduction in the prevalence of hepatitis C virus infection in hemodialysis patients: causes and consequences. Am J Kidney Dis 43(4):685–689

Fakunle YM, Al-Mofarreh M, El-Karamany WM, Ezzat HO, Al-Shora B, El-Drees AZ (1991) Prevalence of antibodies to hepatitis C virus in hemodialysis patients in Riyadh. Ann Saudi Med 11:504–506

Freitas SZ, da Cunha RV et al (2008) Prevalence, genotypes and risk factors associated with hepatitis C virus infection in hemodialysis patients in Campo Grande, MS, Brazil. Mem Inst Oswaldo Cruz 103:405–408

Gallego E, Lopez A, Perez J et al (2006) Effect of isolation measures on the incidence and prevalence of hepatitis C virus infection in hemodialysis. Nephron Clin Pract 104:C1–C6

Ghadir MR, Jafari E, Amiriani MT, Rezvan H, Amini S, Pourshams A (2006) Hepatitis C in Golestan Province, Iran (in Persian). Govaresh 11:158–162

Ghomi HA, Sammak H, Forooghi SI, Sahami M, Bitarafan M (2006) Review of hepatitis B, C and HIV in patients under hemodialysis in Qom Province in 2004. The 3rd Iranian Congress of Virology, Tehran, January 2006

Gohar SA, Khalil RY, Elaish NM, Khedr EM, Ahmed MS (1995) Prevalence of antibodies to hepatitis C virus in hemodialysis patients and renal transplant recipients. J Egypt Public Health Assoc 70:465–484

Gul A, Iqbal F (2003) Prevalence of hepatitis C in patients on maintenance haemodialysis. J Coll Physicians Surg Pak 13:15–18

Haidar NA (2002) Prevalence of hepatitis B and hepatitis C in blood donors and high risk groups in Hajjah, Yemen Republic. Saudi Med J 23:1090–1094

Hassan AA, Khalil R (2000) Hepatitis C in dialysis patients in Egypt: relationship to dialysis duration, blood transfusion, and liver disease. Saudi J Kidney Dis Transplant 11:72–73

Higgins JP, Thompson SG, Deeks JJ, Altman DJ (2003) Measuring inconsistency in meta-analyses. BMJ 327:557–560

Hmaied F, Ben Mamou M, Saune-Sandres K et al (2006) Hepatitis C virus infection among dialysis patients in Tunisia: incidence and molecular evidence for nosocomial transmission. J Med Virol 78:185–191

Hussein MM, Mooij JM, Hegazy MS, Bamaga MS (2007) The impact of polymerase chain reaction assays for the detection of hepatitis C virus infection in a hemodialysis unit. Saudi J Kidney Dis Transplant 18:107–113

Jabbari A, Besharat S, Khodabakhshi B (2008) Hepatitis C in hemodialysis centers of Golestan province, northeast of Iran (2005). Hepat Mon 8:61–65

Jadoul M, Cornu C, Ypersele V, Van Ypersele de Strihou C (1998) Universal precautions prevent hepatitis C virus transmission: a 54 month follow-up of the Belgian Multicenter Study. The Universitaires Cliniques St-Luc (UCL) Collaborative Group. Kidney Int 53:1022–1025

Jadoul M, Poignet JL, Geddes C (2004) The changing epidemiology of hepatitis C virus (HCV) infection in haemodialysis: European multicentre study. Nephrol Dial Transplant 19:904–909

Jasuja S, Gupta AK et al (2009) Prevalence and associations of hepatitis C viremia in hemodialysis patients at a tertiary care hospital. Indian J Nephrol 19:62–67

Jemni S, Ikbel K, Kortas M, Mahjoub J, Ghachem L, Bidet JM, Boukef K (1994) Seropositivity to hepatitis C virus in Tunisian haemodialysis patients. Nouv Rev Fr Hématol 36:349–351

Johnson DW, Dent H et al (2009) Frequencies of hepatitis B and C infections among haemodialysis and peritoneal dialysis patients in Asia-Pacific countries: analysis of registry data. Nephrol Dial Transplant 24:1598–1603

Kafi-abad SA, Rezvan H, Abolghasemi H, Talebian A (2009) Prevalence and trends of human immunodeficiency virus, hepatitis B virus, and hepatitis C virus among blood donors in Iran, 2004 through 2007. Transfusion 49:2214–2220

Kamel MA, Ghaffar YA, Wasef MA, Wright M, Clark LC, Miller FD (1992) High HCV prevalence in Egyptian blood donors. Lancet 340:427

Kashem A, Nusairat I, Mohamad M et al (2003) Hepatitis C virus among hemodialysis patients in Najran: prevalence is more among multi-center visitors. Saudi J Kidney Dis Transplant 14:206–211

Khattab OS (2008) Prevalence and risk factors for hepatitis C virus infection in hemodialysis patients in an Iraqi renal transplant center. Saudi J Kidney Dis Transplant 19:110–115

Kheradpezhouh M, Taremi M, Gachkar L, Aghabozorgi S, Khoshbaten M (2007) Presence and significance of transfusion-transmitted virus infection in Iranian patients on maintenance hemodialysis. J Microbiol Immunol Infect 40:106–111

Khokhar N, Alam AY, Naz F, Mahmud SN (2005) Risk factors for hepatitis C virus infection in patients on long-term hemodialysis. J Coll Physicians Surg Pak 15:326–328

Mahdavi-Mazdeh M, Zamyadi M, Nafar M (2008) Assessment of management and treatment responses in haemodialysis patients from Tehran province, Iran. Nephrol Dial Transplant 23:288

Makhloogh A, Mahdavi MR, Haghshenas M, Ghasemian R, Jamshidi M (2008) Hepatitis C prevalence in hemodialysis patients in Mazandaran, Iran: a survey by polymerase chain reaction and serological methods. J Biol Sci 3:265–268

Mohammad-Alizadeh AH, Ranjbar M, Seifoleslami SAR (2002) The frequency of hepatitis C in dialyse patients in Hamadan Ekbatan hospital. Iran J Infect Dis Trop Med 7:27–34

Moukeh G, Yacoub R, Fahdi F, Rastam S, Albitar S (2009) Epidemiology of hemodialysis patients in Aleppo city. Saudi J Kidney Dis Transplant 20:140–146

Nemati E, Alavian SM, Taheri S, Moradi M, Pourfarziani V, Einolahi B (2009) Hepatitis C virus infection among patients on hemodialysis: a report from a single center in Iran. Saudi J Kidney Dis Transplant 20:147–153

Omar MN, Tashkandy MA, El Tonsy AH (1995) Liver enzymes and protein electrophoretic patterns in hemodialysis patients with antibodies against the hepatitis C virus. Saudi J Kidney Dis Transplant 6:163–166

Othman B, Monem F (2001) Prevalence of antibodies to hepatitis C virus among hemodialysis patients in Damascus, Syria. Infection 29:262–265

Paniagua R, Villasis-Keever A et al (2010) Elevated prevalence of hepatitis B in Mexican hemodialysis patients: a multicentric survey. Arch Med Res 41:251–254

Petitti DB (2000) Meta-analysis, decision analysis, and cost-effectiveness analysis: methods for quantitative synthesis in medicine. Oxford University Press, Oxford

Pol S, Romeo R, Zins B (1993) Hepatitis C virus RNA in anti-HCV positive hemodialyzed patients: significance and therapeutic implications. Kidney Int 44:1097–1100

Qadi AA, Tamim H, Ameen G, Bu-Ali A, Al-Arrayed S, Fawaz NA, Almawi WY (2004) Hepatitis B and hepatitis C virus prevalence among dialysis patients in Bahrain and Saudi Arabia: a survey by serologic and molecular methods. Am J Infect Control 32:493–495

Rais-Jalali Gh, Khajehdehi P (1999) Anti-HCV seropositivity among haemodialysis patients of Iranian origin. Nephrol Dial Transplant 14:2055–2056

Reddy AK, Murthy KV et al (2005) Prevalence of HCV infection in patients on haemodialysis: survey by antibody and core antigen detection. Indian J Med Microbiol 23:106–110

Rezvan H, Abolghassemi H, Kafiabad SA (2007) Transfusion-transmitted infections among multitransfused patients in Iran: a review. Transfus Med 17:425–433

Saab S, Brezina M, Gitnick G, Martin P, Yee HF (2001a) Hepatitis C screening strategies in hemodialysis patients. Am J Kidney Dis 38:91–97

Saab S, Martin P, Brezina M, Gitnick G, Yee HF (2001b) Serum alanine aminotransferase in hepatitis C screening of patients on hemodialysis. Am J Kidney Dis 37:308–315

Saboor B, Boroomand P, Mehrabi Y, Ghanbari M, Zarrinfam H (2003) Prevalence and risk factors of hepatitis C infection in hemodialysis patients (Kermanshah, 1999–2000) (in Persian). Behbood 7:60–66

Said RA, Hamzeh YY, Mehyar NS, Rababah MS (1995) Hepatitis C virus infection in hemodialysis patients in Jordan. Saudi J Kidney Dis Transplant 6:140–143

Salama G, Rostaing L, Sandres K, Izopet J (2000) Hepatitis C virus infection in French hemodialysis units: a multicenter study. J Med Virol 61:44–51

Samimi-Rad K, Hosseini M, Shahbaz B (2008) Hepatitis C virus infection and HCV genotypes of hemodialysis patients. Iranian J Publ Health 37:146–152

Saxena AK, Panhotra BR, Naguib M, Aboras MN, Sundaram DS, Venkateshappa CK, Khan WU (2001) Prevalence of hepatitis C antibodies among hemodialysis patients in Al-hasa region of Saudi Arabia. Saudi J Kidney Dis Transplant 12:562–565

Saxena Ak, Panhotra BR, Sundaram DS et al (2003) Impact of dedicated space, dialysis equipment, and nursing staff on the transmission of hepatitis C virus in a hemodialysis unite of the Middle East. Am J Infect Control 31:26–33

Sekkat S, Kamal N, Benali B et al (2008) Prevalence of anti-HCV antibodies and seroconversion incidence in five haemodialysis units in Morocco. Néphrol Thér 4:105–110

Seyrafian S, Mobasherizadeh S, Javadi A, Akhzari M, Esfandiari J (2006) Comparison and prevalence of hepatitis B and C infection and hepatitis B vaccination in hemodialysis patients and staffs in 13 hemodialysis centers in Isfahan (Iran). Nephrol Dial Transplant 21(Suppl 4):484

Shaheen FA, Huraib SO, al-Rashed R et al (1995) Prevalence of hepatitis C antibodies among hemodialysis patients in the Western province of Saudi Arabia. Saudi J Kidney Dis Transplant 6:136–139

Shamshirsaz AA, Kamgar M, Bekheirnia MR et al (2004) The role of hemodialysis machines dedication in reducing Hepatitis C transmission in the dialysis setting in Iran: a multicenter prospective interventional study. BMC Nephrol 5:13

Somi MH, Ardalan MR, Sokhanvar H, Pouri AA (2007) Hepatitis C virus infection in dialysis centers of Tabriz, Iran: a multicenter study. Iran J Clin Infect Dis 2:23–26

Soni PN, Tait DR et al (1993) Hepatitis C virus antibodies among risk groups in a South African area endemic for hepatitis B virus. J Med Virol 40:65–68

Sorkhi H, Roushan MR, Al Hashemi GH, Dooki MR, Bai S (2008) Response to hepatitis B virus vaccination in haemodialysis patients with and without hepatitis C infection. East Mediterr Health J 14:798–803

Souqiyyeh MZ, Shaheen FA, Huraib SO, Al-Khader AA (1995) The annual incidence of seroconversion of antibodies to the hepatitis C virus in the hemodialysis population in Saudi Arabia. Saudi J Kidney Dis Transplant 6:167–173

Soyannwo MA, Khan N, Kommajosyula S et al (1996) Hepatitis C antibodies in haemodialysis and pattern of end-stage renal failure in Gassim, Saudi Arabia. Afr J Med Med Sci 25:13–22

Suliman SM, Fessaha S, El Sadig M, El-Hadi MB, Lambert S, Fields H, Ghalib HW (1995) Prevalence of hepatitis C virus infection in hemodialysis patients in Sudan. Saudi J Kidney Dis Transplant 6:154–156

Taziki O, Espahbodi F (2008) Prevalence of hepatitis C virus infection in hemodialysis patients. Saudi J Kidney Dis Transplant 19:475–478

Toosi MN, Larti F, Seifei S, Abdollahi A (2008) Prevalence of viral hepatitis in hemodialysis patients in Teheran, Iran. J Gastrointestin Liver Dis 17:233–234

Tu AW, Buxton JA et al (2009) Prevalence and incidence of hepatitis C virus in hemodialysis patients in British Columbia: follow-up after a possible breach in hemodialysis machines. Can J Infect Dis Med Microbiol 20:e19–e23

Yang CS, Chang HH, Chou CC, Peng SJ (2003) Isolation effectively prevents the transmission of hepatitis C virus in the hemodialysis unit. J Formos Med Assoc 102:79–85

Zampieron A, Jayasekera H et al (2006) Sero-conversion of HCV negative patients: a European study on the epidemiology and management of HCV haemodialysis patients. EDTNA ERCA J 32:45–50